

FORM PTO-1390(Modified) (REV 11-2000)		U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371				14971
INTERNATIONAL APPLICATION NO. PCT/EP00/06077		INTERNATIONAL FILING DATE 29 June 2000 (29.06.00)		U.S. APPLICATION NO. (IF KNOWN) SEE 37 CFR Unassigned <b>107030799</b>
TITLE OF INVENTION <b>METHOD FOR PRODUCING A BALL-AND-SOCKET JOINT BETWEEN A SLIPPER AND A PISTON, AND A BALL-AND-SOCKET JOINT OF THIS TYPE</b>		PRIORITY DATE CLAIMED 21 July 1999 (21.07.99)		
APPLICANT(S) FOR DO/EO/US Steven Donders				
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:				
<ol style="list-style-type: none"> <li>1. <input checked="" type="checkbox"/> This is a <b>FIRST</b> submission of items concerning a filing under 35 U.S.C. 371.</li> <li>2. <input type="checkbox"/> This is a <b>SECOND</b> or <b>SUBSEQUENT</b> submission of items concerning a filing under 35 U.S.C. 371.</li> <li>3. <input checked="" type="checkbox"/> This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (24) indicated below.</li> <li>4. <input checked="" type="checkbox"/> The US has been elected by the expiration of 19 months from the priority date (Article 31).</li> <li>5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2))             <ol style="list-style-type: none"> <li>a. <input type="checkbox"/> is attached hereto (required only if not communicated by the International Bureau).</li> <li>b. <input checked="" type="checkbox"/> has been communicated by the International Bureau.</li> <li>c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US).</li> </ol> </li> <li>6. <input checked="" type="checkbox"/> An English language translation of the International Application as filed (35 U.S.C. 371(c)(2))             <ol style="list-style-type: none"> <li>a. <input checked="" type="checkbox"/> is attached hereto.</li> <li>b. <input type="checkbox"/> has been previously submitted under 35 U.S.C. 154(d)(4).</li> </ol> </li> <li>7. <input checked="" type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))             <ol style="list-style-type: none"> <li>a. <input type="checkbox"/> are attached hereto (required only if not communicated by the International Bureau).</li> <li>b. <input type="checkbox"/> have been communicated by the International Bureau.</li> <li>c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired.</li> <li>d. <input checked="" type="checkbox"/> have not been made and will not be made.</li> </ol> </li> <li>8. <input type="checkbox"/> An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).</li> <li>9. <input checked="" type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).</li> <li>10. <input type="checkbox"/> An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).</li> <li>11. <input checked="" type="checkbox"/> A copy of the International Preliminary Examination Report (PCT/IPEA/409).</li> <li>12. <input checked="" type="checkbox"/> A copy of the International Search Report (PCT/ISA/210).</li> </ol>				
Items 13 to 20 below concern document(s) or information included:				
<ol style="list-style-type: none"> <li>13. <input checked="" type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98.</li> <li>14. <input checked="" type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.</li> <li>15. <input checked="" type="checkbox"/> A <b>FIRST</b> preliminary amendment.</li> <li>16. <input type="checkbox"/> A <b>SECOND</b> or <b>SUBSEQUENT</b> preliminary amendment.</li> <li>17. <input type="checkbox"/> A substitute specification.</li> <li>18. <input type="checkbox"/> A change of power of attorney and/or address letter.</li> <li>19. <input type="checkbox"/> A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.</li> <li>20. <input type="checkbox"/> A second copy of the published international application under 35 U.S.C. 154(d)(4).</li> <li>21. <input type="checkbox"/> A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).</li> <li>22. <input checked="" type="checkbox"/> Certificate of Mailing by Express Mail</li> <li>23. <input checked="" type="checkbox"/> Other items or information:</li> </ol>				
<b>Two (2) Sheets of Drawings</b> Assignee: Brueninghaus Hydromatik GmbH of Elchingen, Germany				

U.S.APPLICATIONNO.(IF KNOWN SEE 37 CFR Unassigned	INTERNATIONAI APPLICATIONNO. PCT/EP00/06077	ATTORNEY'S DOCKET NUMBER 14971																			
24. The following fees are submitted:		CALCULATIONS PTO USE ONLY																			
<b>BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :</b>																					
<input type="checkbox"/> Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO ..... \$1040.00 <input checked="" type="checkbox"/> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO ..... \$890.00 <input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO ..... \$740.00 <input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) ..... \$710.00 <input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) ..... \$100.00																					
<b>ENTER APPROPRIATE BASIC FEE AMOUNT =</b>		\$890.00																			
Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).																					
<table border="1"> <thead> <tr> <th>CLAIMS</th> <th>NUMBER FILED</th> <th>NUMBER EXTRA</th> <th>RATE</th> </tr> </thead> <tbody> <tr> <td>Total claims</td> <td>* 15 - 20 =</td> <td>0</td> <td>x \$18.00 \$0.00</td> </tr> <tr> <td>Independent claims</td> <td>* 3 - 3 =</td> <td>0</td> <td>x \$84.00 \$0.00</td> </tr> <tr> <td colspan="3">Multiple Dependent Claims (check if applicable)</td> <td><input type="checkbox"/> \$0.00</td> </tr> <tr> <td colspan="2"><b>TOTAL OF ABOVE CALCULATIONS =</b></td> <td>\$890.00</td> </tr> </tbody> </table>			CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	Total claims	* 15 - 20 =	0	x \$18.00 \$0.00	Independent claims	* 3 - 3 =	0	x \$84.00 \$0.00	Multiple Dependent Claims (check if applicable)			<input type="checkbox"/> \$0.00	<b>TOTAL OF ABOVE CALCULATIONS =</b>		\$890.00
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<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27). The fees indicated above are reduced by 1/2. <b>SUBTOTAL = \$890.00</b>																					
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). <b>TOTAL NATIONAL FEE = \$890.00</b>																					
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (check if applicable). <b>TOTAL FEES ENCLOSED = \$890.00</b>																					
* Claim calculation based on claims as amended by Preliminary Amendment being filed concurrently herewith.		Amount to be: <input type="checkbox"/> refunded <input type="checkbox"/> charged \$ _____																			

- a.  A check in the amount of \$890.00 to cover the above fees is enclosed.
- b.  Please charge my Deposit Account No. \_\_\_\_\_ in the amount of \_\_\_\_\_ to cover the above fees. A duplicate copy of this sheet is enclosed.
- c.  The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 19-1013/SSMP A duplicate copy of this sheet is enclosed.
- d.  Fees are to be charged to a credit card. WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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SIGNATURE

Leopold Presser

NAME

19,827

REGISTRATION NUMBER

January 11, 2002

DATE

10/030799

531 Rec'd PCT/FTC 11 JAN 2002

PATENTS

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

**Applicant(s):** Steven Donders

**Examiner:** Unassigned

**Serial No:** Unassigned

**Art Unit:** Unassigned

**Filed:** Herewith

**Docket:** 14971

**For:** METHOD FOR PRODUCING A  
BALL-AND-SOCKET JOINT BETWEEN A SLIPPER  
AND A PISTON, AND A BALL-AND-SOCKET JOINT  
OF THIS TYPE

**Dated:** January 11, 2002

Assistant Commissioner for Patents  
Washington, D.C. 20231

PRELIMINARY AMENDMENT

Sir:

In connection with the filing of the above-identified application, kindly enter  
the following preliminary amendments.

In the claims:

Please amend claims 3-5, 11 and 12 as follows:

3.(Amended) Method according to claim 1, characterized in that the recess edge (7) is hot-beaded.

4.(Amended) Method according to claim 1, characterized in that, before finishing the lateral surface (2c) of the piston (2), the lateral surface (2c) is nitrided or hardened.

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Date of Deposit: January 11, 2002

I hereby certify that this correspondence is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 C.F.R. § 1.10 on the date indicated above and is addressed to the Assistant Commissioner for Patents and Trademarks, Washington, D.C. 20231 on January 11, 2002.

Dated: January 11, 2002

Michelle Mustafa

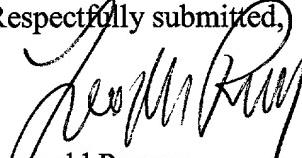
- 5.(Amended) Method according to claim 1, characterized in that the recess edge (7) is shaped with a conical from converging towards its free edge.
- 11.(Amended) Ball-and-socket joint according to claim 7, characterized in that the recess edge (7) is shaped to converge towards its free end.
- 12.(Amended) Ball-and-socket joint according to claim 7, characterized in that the piston (2) and/or the slipper (3) is or are hardened.
- Please add new claims 13-15 as follows:
- 13.(New) Method according to claim 4, characterized in that, before finishing the lateral surface (2c) of the piston (2), the lateral surface (2c) is gas-nitrided.
- 14.(New) Ball-and-socket joint according to claim 11, characterized in that the recess edge (7) is shaped with a conical form converging towards its free end.
- 15.(New) Ball-and-socket joint according to claim 12, characterized in that the piston (2) and/or the slipper (3) is nitride-hardened.

REMARKS

As originally amended pursuant to PCT Article 34, claims 4, 5 and 12 did not comply with the multiple dependent claim style specified by U.S. Law. The amendments submitted above have been made to delete all multiple dependent claims.

Attached hereto is a marked-up version of changes made to the claims by the current amendment. The attached page is captioned "Version with Markings to Show Changes Made."

It is respectfully requested that the above amendments be entered before an action on the merits is issued.

Respectfully submitted,  
  
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EWG/LP:dg

FEDERAL BUREAU OF INVESTIGATION

10/030799  
531 Rec'd PCT/PT 11 JAN 2002

Application No. Unassigned

**VERSION WITH MARKINGS TO SHOW CHANGES MADE**

**In the claims:**

Claims 3-5, 11 and 12 has been amended as follows:

3.(Amended) Method according to Claim 1 [or 2], characterized in that the recess edge (7) is hot-beaded.

4.(Amended) Method according to [one of the preceding claims] claim 1, characterized in that, before finishing the lateral surface (2c) of the piston (2), the lateral surface (2c) is nitrided or hardened [, in particular gas-nitrided].

5.(Amended) Method according to [one of Claims] claim 1 [to 3], characterized in that the recess edge (7) is shaped with a conical form converging towards its free edge.

11.(Amended) Ball-and-socket joint according to [one of Claims] claim 7 [to 10], characterized in that the recess edge (7) is shaped to converge [, in particular conically,] towards its free end.

12.(Amended) Ball-and-socket joint according to [one of the preceding Claims] claim 7 [to 11], characterized in that the piston (2) and/or the slipper (3) is or are hardened [, in particular nitride-hardened].

Method for producing a ball-and-socket joint  
between a slipper and a piston, and a ball-and-socket joint  
of this type

- 5 The invention relates to a method according to the precharacterising clause of Claim 1 or 2 and a ball-and-socket joint according to the precharacterising clause of Claim 7.
- 10 A method according to the precharacterising clause of Claim 1 is described in DE 197 34 217 A1. In this known method, after connection to the slipper, the piston, prefabricated with a cross-section overmeasure, is positively connected to the slipper by cold-beading a recess edge radially protruding from the lateral surface, is then hardened at its lateral surface and then finished, in particular ground, at its lateral surface. This known method involves considerable expenditure of labour, the machining operation being the final operation. Moreover, considerable widening of the beading is to be expected, which can be attributed to the fact that the considerable stresses occurring during the cold working cause the beading to spring back and consequently the beading grips behind the joint ball only with comparatively large freedom of movement. Furthermore, this ball-and-socket joint is restricted to a comparatively soft material for the slipper, since harder materials cannot be beaded.

- The object on which the invention is based is to simplify a method, and design a ball-and-socket joint, according to the precharacterising clause of Claim 1, 2, and 7, in such a way that improved and/or more cost-effective production is possible.
- 30 This object is achieved by the features of Claim 1 or 2, and 7.

In the inventive method according to Claim 1, the lateral surface of the piston is finished before it is connected to

the slipper and the recess edge is beaded after the hemispherical recess and the joint ball have been brought together. The bringing-together and connection of the piston and the slipper are thus the final steps of the  
5 method. In other words, all the other method steps can be carried out respectively on the parts of the ball-and-socket joint when they are still single, thereby significantly simplifying the handling of the parts and their positioning in the respective method step. Moreover,  
10 soiling of the ball-and-socket joint is avoided, since in the method according to the invention dirt which has accumulated previously can be simply cleaned off the surfaces of the joint before the piston and the slipper are brought together and connected, and after connection no  
15 more dirt accumulation occurs.

In contrast to the known method, in which the recess edge is cold-beaded, the method according to the invention involves structural transformation of the material by  
20 heating the recess edge, it being possible for this method step to be followed by two different method steps. On the one hand, the material of the recess edge is heated to a temperature such that the material structure undergoes a transformation to a material structure which is soft even  
25 in the cold state, after which the recess edge can be deformed by cold beading into a form in which it positively grips behind the joint ball. It is, however, also possible to heat the material, according to Claim 3, to a temperature at which the strength of the material is  
30 reduced, in order to carry out hot beading at this temperature, the material being plastically deformable with comparatively low deformation forces. This requires lower deformation forces than those required in cold beading. The hot beading with lower deformation forces is particularly  
35 advantageous in order to not to impair the joint ball or the surface thereof during deformation of the recess edge

and, moreover, in order to maintain a desired freedom of movement between the joint ball and the recess edge.

The above-described advantages also apply analogously to  
5 the inventive method according to Claim 2 for producing a ball-and-socket joint in which the recess edge is arranged on the slipper.

Not only does a hot beading according to Claim 3 or 7  
10 permit the use of a material of higher strength, in particular steel, for the recess edge or piston and/or the slipper, but it can also be carried out with lower material stresses, so that the hot beading can be produced more accurately on account of lower elastic back-stresses and  
15 the ball-and-socket joint can be produced with smaller freedom of movement, avoiding impairment of the surface of the joint ball during the hot beading.

It is also advantageous to shape the recess edge with its  
20 outer lateral surface in a form converging, in particular conically, towards its free edge. As a result, the deformation forces required for the beading and also material loads resulting therefrom are further reduced. On the other hand, it has been found that such a tapering  
25 recess edge is able to absorb the axial forces (piston return forces) occurring during the operation of the piston machine safely, both when the recess edge consists of a metal with a good sliding property, such as, for example, brass or bronze, or of steel, which has a higher strength  
30 compared with the aforementioned sliding material. In cases where the slipper requires a high strength and at the same time a good sliding property, it is advisable to produce the slipper from metal with a high strength or hardness, in particular steel, and to design it in its base region with  
35 a sliding part forming its base surface.

Another measure for hardening the surfaces of the piston and/or slipper and at the same time ensuring a softer core, thereby achieving a high breaking strength, can be achieved by nitriding or gas-nitriding the surface of the piston  
5 and/or slipper.

A ball-and-socket joint according to the invention can be configured by forming the joint recess on the slipper or on the piston and the joint ball on whichever is the other  
10 joint part. The arrangement of the joint recess on the piston permits particularly favourable utilisation of the lateral surface of the piston as a guide surface, thus enabling a particularly short design of the piston machine to be achieved.

15 The invention and further advantages which can be obtained by means of the invention are explained in more detail below with the aid of advantageous configurations and drawings, in which

20 Fig. 1 shows, in axial section, a ball-and-socket joint according to the invention between a slipper and a piston;

25 Fig. 2 shows a recess edge of the piston in a prefabricated form;

Fig. 3 shows the ball-and-socket joint in a modified configuration.

30 The ball-and-socket joint, denoted generally by 1, connects a piston 2, preferably made of steel, and a slipper 3, preferably made of bronze or brass (Fig. 1) or likewise made of steel (Fig. 3), while ensuring pivoting movements  
35 between the piston 2 and the slipper 3 which are limited on all sides. The centre axes of the piston 2 and the slipper 3 are denoted by 2a and 3a.

The ball-and-socket joint 1 comprises a spherical-cap-shaped or spherical-segment-shaped joint recess 5 with a depth  $a$  which is greater than the ball radius  $r$  of a joint ball 4 mounted pivotably therein, a recess edge 7 that  
5 protrudes axially beyond the equator 6 of the joint recess 5 gripping behind the joint ball 4 and at the same time following the convergent form of the joint ball in this ball ring zone while maintaining freedom of movement. As can be seen from Fig. 1, the axial length  $b$  of the recess  
10 edge 7 is dimensioned with a length such that it extends into the corner region between the joint ball 4 and a ball neck or a base part 8 of the slipper 3, in the maximum pivoted position illustrated in Fig. 1. In the present exemplary embodiment, the recess edge 7 tapers towards its  
15 free end, the outer lateral surface preferably being a conical surface.

The cylindrical piston 2 is preferably a hollow piston, of which the hollow space 9, configured in particular as an  
20 annular space, extends from a rear base section 11, in which the joint recess 5 is arranged, up to a front end section 12, which forms a cover and is preferably connected to the circumferential wall of the remaining part of the piston by a friction welding process. A broken line  
25 indicates the joint between the welded parts which is present before the friction welding process. The preferably annular hollow space 9 encloses a cylindrical central stem 13, which extends forwards in one piece from the base section 11 and is likewise connected by friction welding to  
30 the end section 12 or a central-stem projection set off from it. This also applies to the circumferential wall 15 of the piston 2, which wall is hollow-cylindrical in the region of the hollow space 9 and likewise extends forwards in one piece from the base section 11 and is connected by  
35 friction welding to the end section 12 or a circumferential-wall projection 16 arranged around it. Inwardly from the weld, denoted generally by 17, the

central stem 13 is radially supported on the circumferential wall 15 by an annular disc 18, the annular disc 18 bearing against an inner shoulder surface 13a preferably present on the circumferential wall 15.

5

Extending longitudinally in each case through the piston 2 and the slipper 3 is a channel 19a, 19b, which opens into a shallow recess 22 arranged at the plane bottom surface 21 of the slipper 3. When the hydrostatic machine is in operation, the working pressure in the hydraulic medium can be transmitted through the channels 19a, 19b up to the recess 22, where the hydraulic medium brings about lubrication and the pressure brings about a pressure relief in a manner known per se.

10

The piston 2 preferably consists of hardenable steel, in particular steel which can be hardened by nitride hardening. To increase the strength and hardness, its lateral surface is preferably nitrided and hardened.

15

The present ball-and-socket joint 1 is suitable for the pivotable support of a piston 2 for piston machines, in particular axial piston machines, on a supporting surface S, against which the bottom surface 21 of the slipper 3 bears. In an axial piston machine, the supporting surface S may be the oblique surface of a so-called swash plate.

20

In the text which follows, a description is given of the establishment of a preferred method for producing the piston arrangement comprising the piston 2 and the slipper 3 connected non-detachably thereto. The slipper 3 may be produced as a completely finished component on a large scale and placed in readiness for connection to the piston 2.

25

The piston 2 is preferably prefabricated likewise on a large scale as a prefabricated piston blank and placed in

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readiness. In this prefabricated form, the recess edge 7 extends axially with an inside diameter d which can be adapted to the diameter of the joint ball 4 or the joint recess 5 while allowing for freedom of movement, so that 5 the joint ball 4 can be introduced into the joint recess 5. At the same time, the front end part 12 and the remaining part 2b of the piston are produced with a cross-section overmeasure x, which after welding is hardened, optionally after prior nitriding, and is finished by machining, for 10 example by grinding. The method steps before or after welding, namely the formation of the hollow space 9, the joint recess 5 and the channel 19a, may be in any order. What is essential is that the positive connection of the joint ball 4 to the piston 2 is created as the final 15 operation, after the nitriding and/or hardening and finishing of the lateral surface 2c.

For connection, the joint ball 4 and the joint recess 5 are pushed together and the slipper 3 is optionally held in its 20 central position, which may be effected by supporting it. Then, the recess edge 7 is heated by means of a suitable heating device, for example in the form of a heating ring 23 (illustrated schematically) with a width approximately equal to the axial length b, to a temperature at which the 25 hardness of the material is reduced, so that even after the material has cooled the recess edge 7 can be beaded with low deformation forces or can be heated to a temperature at which the strength of the material is reduced and the recess edge can be hot-beaded. In both cases, the recess 30 edge can be beaded plastically into the form illustrated in Fig. 1 with relatively low forces.

The comparatively low deformation forces ensure that the recess edge 7 is deformed without mechanically overloading 35 the slipper 3, which consists, for example, of softer material. The heating may be effected by direct heating, for example by means of a flame, or inductively by an

inductive electric heating device. As a result of the local heating of the recess edge 7, the hardened material in this region becomes soft again and can thus be readily deformed without the remaining region of the piston 2 suffering substantially losses in hardness.

- An essential advantage of the method according to the invention is that the piston 2 can be completely finished before fitting together with and connection to the slipper 10 3 without special measures with regard to the beading being required during the above-described heating, such as, for example, covering the recess edge 7 to be deformed, during the nitriding, in particular gas nitriding, turning off regions which have already been nitrided, before the 15 beading, etc. By fine-tuning the heating, beading and cooling operations, the optimum play of the ball-and-socket joint 1 can be set very easily and reliably reproduced even in series production.
- 20 The exemplary embodiment according to Fig. 3, in which identical or comparable parts are provided with the same reference symbols, differs from the above-described exemplary embodiment in that the joint ball 4 is formed on the piston 2 preferably in one piece and the slipper 3 has 25 the joint recess 5. In this configuration, the piston 2 is completely fabricated with the joint ball 4, so that it is ready to be brought together with the slipper 3. In this exemplary embodiment, too, the order of the individual method steps during the production of the piston 2 may 30 vary.

The slipper 3 is prefabricated with the joint recess 5 and a recess edge 7, as has already been illustrated and described in Fig. 2, so that repeated description is not 35 necessary. However, in the exemplary embodiment according to Fig. 3, the slipper 3 consists of a hard material such as, for example, steel or preferably nitridable and/or

hardenable steel, and to improve the sliding property a sliding part 8a made of a material with a good sliding property, e.g. bronze or brass, which is preferably plate-shaped and forms the base surface 21 of the slipper 3, is  
5 provided and is inserted, for example, into a recess 8b and fastened, for example, by soldering or adhesive bonding.

In the final method step for producing the piston arrangement according to Fig. 3, the ball-and-socket joint  
10 1 is created or completed, in accordance with the exemplary embodiment already described, by introducing the joint ball 4 into the joint recess 5 and then heating and hot-beading the recess edge 7.

Claims

1. Method for producing a ball-and-socket joint (1) between a slipper (3) and a piston (2) of a piston machine, having the following method steps:
- configuring the slipper (3) with a joint ball (4) at the end opposite its bottom surface (21),
  - configuring the piston (2) with an overmeasure (x) on its lateral surface (2c) and with a hemispherical joint recess (5) with a recess edge (7) that protrudes beyond the equator (6) of the joint recess (5) at one end of the piston (2), for the joint ball (4),
  - bringing together the joint recess (5) and the joint ball (4),
  - beading the recess edge (7) into a form in which it grips behind the joint ball (4)
  - and finishing the lateral surface (2c) of the piston (2), characterised by the following method steps:
    - bringing together the joint recess (5) and the joint ball (4) after finishing the lateral surface (2c) of the piston (2),
    - locally heating the recess edge (7) to a temperature that reduces its hardness and
    - beading the recess edge (7).
2. Method for producing a ball-and-socket joint (1) between a slipper (3) and a piston (2) of a piston machine, having the following method steps:
- configuring the piston (2) with a joint ball (4) at one end,
  - configuring the slipper (3) with a joint recess (5) with a recess edge (7) that protrudes beyond the equator (6) of the joint recess (5), for the joint ball (4),
  - bringing together the joint recess (5) and the joint ball (4)

- and beading the recess edge (7) into a form in which it positively grips behind the joint ball (4), characterised by the following method steps:

- 5 - locally heating the recess edge (7) to a temperature that reduces the hardness of the material after the bringing-together and  
- beading the recess edge (7) into a form in which it positively grips behind the joint ball (4).

10

3. Method according to Claim 1 or 2, characterised in that the recess edge (7) is hot-beaded.

15 4. Method according to one of the preceding claims, characterised in that, before finishing the lateral surface (2c) of the piston (2), the lateral surface (2c) is nitrided or hardened, in particular gas-nitrided.

20 5. Method according to one of Claims 1 to 3, characterised in that the recess edge (7) is shaped with a conical form converging towards its free edge.

6. Method according to Claim 5, characterised in that the converging form is produced without an overmeasure (x).

25

7. Ball-and-socket joint (1) between a piston (2) and a slipper (3) of a piston machine, having a spherical joint recess (5) on one part of the ball-and-socket joint,

30 in which recess a spherical joint ball (4) on another part of the ball-and-socket joint is pivotably mounted, a recess edge (7) of the joint recess (5) being beaded into a position in which it grips behind the joint ball (4), characterised in that the recess edge (7) is hot-beaded.

35

8. Ball-and-socket joint according to Claim 7, characterised in that the joint recess (5) and the recess

edge (7) are arranged on the piston (2) and the joint ball (4) is arranged on the slipper (3).

9. Ball-and-socket joint according to Claim 7,  
5 characterised in that the joint recess (5) and the recess edge (7) are arranged on the slipper (3) and the joint ball (4) is arranged on the piston (2).

10. Ball-and-socket joint according to Claim 9,  
10 characterised in that the slipper (3) consists of metal with a high strength or hardness, in particular steel, and in its base region has a sliding part (8a) forming its base surface (21).

15 11. Ball-and-socket joint according to one of Claims 7 to 10, characterised in that the recess edge (7) is shaped to converge, in particular conically, towards its free end.

12. Ball-and-socket joint according to one of the  
20 preceding Claims 7 to 11, characterised in that the piston (2) and/or the slipper (3) is or are hardened, in particular nitride-hardened.

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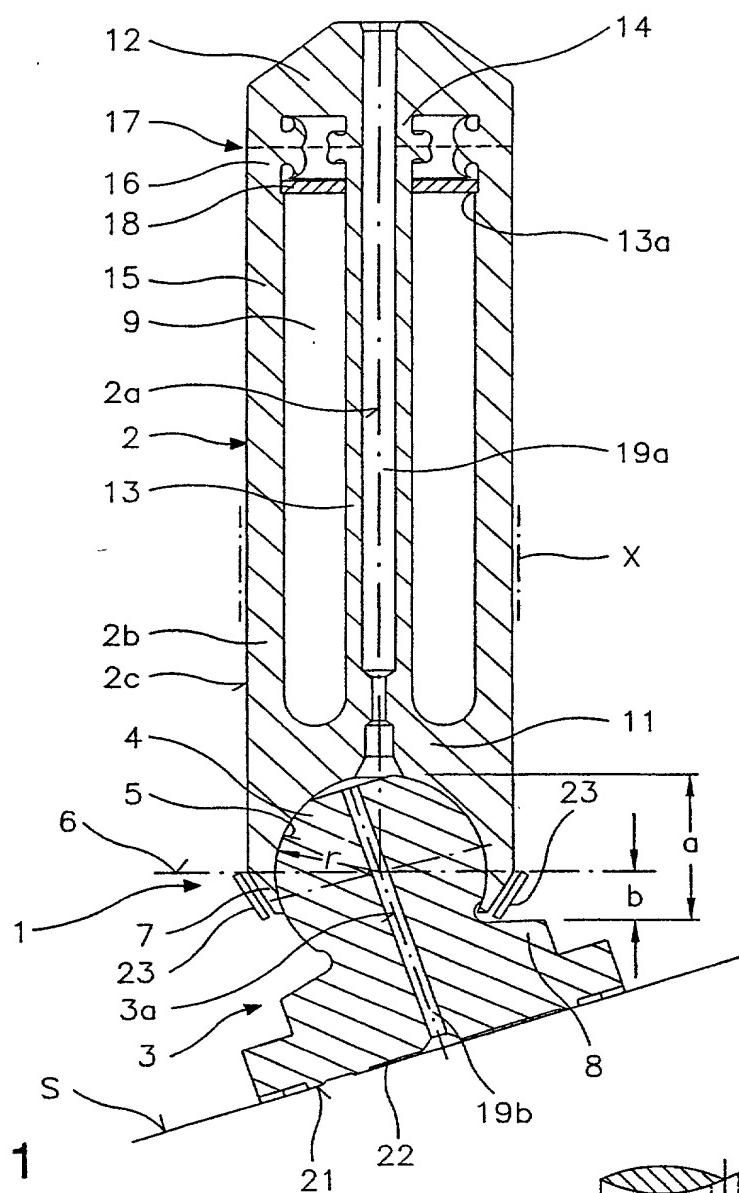


Fig. 1

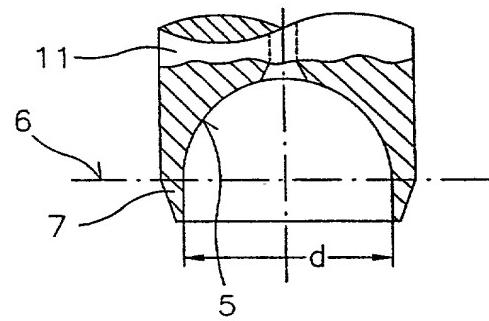


Fig. 2

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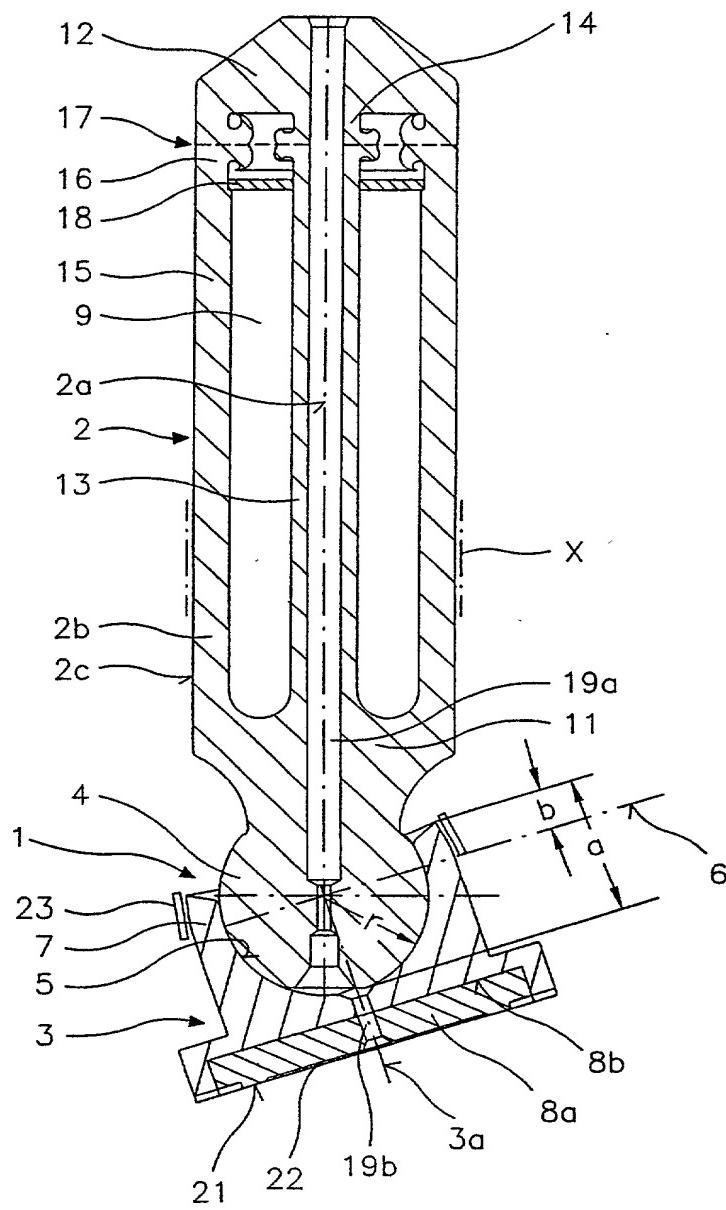


Fig. 3

# Declaration and Power of Attorney For Patent Application

## English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

**METHOD FOR PRODUCING A BALL-AND-SOCKET JOINT BETWEEN  
A SLIPPER AND A PISTON, AND A BALL-AND-SOCKET JOINT OF THIS TYPE**

the specification of which

(check one)

is attached hereto.

was filed on June 29, 2000 as United States Application No. or PCT International

Application Number PCT/EP00/06077

and was amended on \_\_\_\_\_

(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

(check one) I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

### Prior Foreign Application(s)

### Priority Not Claimed

199 34 218.0

(Number)

Germany

(Country)

21/July/1999

(Day/Month/Year Filed)

(Number)

(Country)

(Day/Month/Year Filed)

(Number)

(Country)

(Day/Month/Year Filed)

I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional application(s) listed below:

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(Application Serial No.)

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(Filing Date)

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(Application Serial No.)

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(Filing Date)

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(Application Serial No.)

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(Filing Date)

I hereby claim the benefit under 35 U. S. C. Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C. F. R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

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(Application Serial No.)

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(Filing Date)

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(Status)  
(patented, pending, abandoned)

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(Application Serial No.)

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(Filing Date)

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(Status)  
(patented, pending, abandoned)

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(Application Serial No.)

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(Filing Date)

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(Status)  
(patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

**POWER OF ATTORNEY:** As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (*list name and registration number*)

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Second inventor's signature	Date
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Citizenship	
Post Office Address	